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ROOST SITES AND FLIGHT PATTERNS OF CANADA GEESE IN WINTER[1]

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Abstract: Observation of a large wintering flock of Canada geese (*Branta canadensis interior*) revealed the existence of relatively exclusive subflocks which consistently utilized specific areas for roosting and maintained recognizable patterns of flight direction. Roost and feed-field locations of radio-marked geese showed that consistent patterns were a result of habitual use of areas by families whereas single geese were more variable. Habitual patterns are apparently motivated by fear of unfamiliar situations and function to enable family members to reunite after separation occurs, to aid efficient use of food, and to minimize the amount and intensity of aggressive conflicts within a flock. Roost and flight patterns of singles varied because of their following nature and submissive rank position within the flock. It is suggested that some subflocks represent a continued association of geese from the same local nesting area rather than just local stratification after migration. Subflock formation in some cases could affect local (or even total) harvest and interpretation of banding and other sampling data in the study of goose populations.

A distinctive feature of large flocks of Canada geese in winter is their regularity as a whole in utilization of specific areas. However, data on the relationship of individuals, especially of different social classes, within a flock have been generally lacking because of the difficulty of repeatedly observing marked birds in large flocks. Development of radio-telemetry has enabled documentation of an individual's movements and habitat utilization. These specific data can provide the basis for suggesting the functions and causes of an animal's daily activity patterns. The purpose of this paper is to present and discuss results of a study of roost-site use and flight patterns of radio-marked Canada geese in winter and to compare these data to gross patterns evident for an entire flock of thousands.

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METHODS

Field work was carried out from late September to mid-March in 1963–64 and 1964–65 mainly at Crab Orchard National Wildlife Refuge, Williamson County, Illinois. The inviolate portion of the refuge, which contained nearly all the geese, was 22,000 acres in size including 2,600 acres of Crab Orchard Lake, 5,000 acres of intertilled cropland (corn, soybeans, hay rotation, and some winter wheat), and 2,800 acres of permanent pasture (mostly fescue). Crab Orchard Lake was created by damming Crab Orchard Creek in 1938. Average water depth is 9 ft. Much of the shoreline is characterized by vertical, eroded clay banks. Water levels are lowered in the autumn to control erosion, thus exposing mud flats around the perimeter which are heavily used by loafing geese. Except for occasional patches of smartweeds (*Polygonum* sp.) and spike-rush (*Eleocharis* sp.) available on these mud flats when the lake is low, the entire lake is largely devoid of

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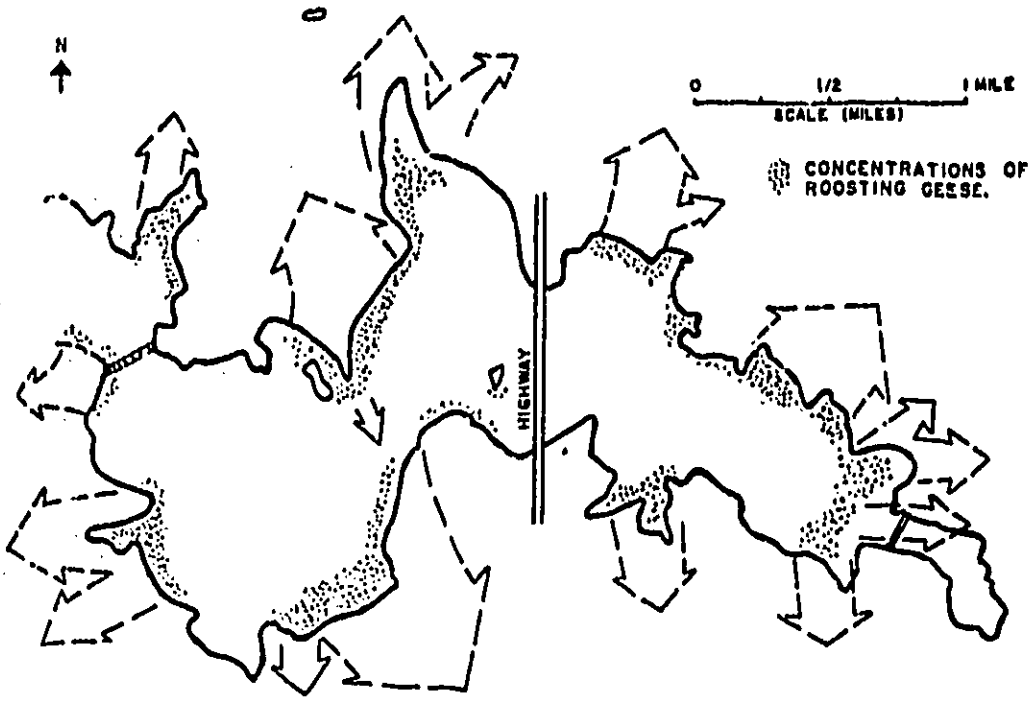

Fig. 1. Major roost locations and directions of flight of Canada geese from Crab Orchard Lake, especially October through December.

natural vegetation utilizable as food by waterfowl.

Forty Canada geese in 1963–64 and 37 in 1964 were color- and radio-tagged to allow recording of their locations and observation of their behavior. Marked geese included all or parts of 10 families, two pairs, and 35 yearlings. Data recorded from transmitter-marked geese were as follows: lake location prior to morning flight, time of flight, location in fields, time of flight to lake or changes of feeding areas, midday roost locations, time of afternoon flights and field locations, and time of flight to the lake in the evenings. Details of the capture, recognition of, and permanency of families and other social classes of geese, and techniques of color-marking and radio-tracking are provided in Raveling (1969).

Additional observations of goose behavior were obtained at Horseshoe Lake (Alexander County) and Union County Wildlife Refuges. These refuges are smaller than Crab Orchard (about 7,000 acres each) but usually contained larger goose populations. Water areas at these refuges are much smaller than at Crab Orchard and much larger acreages of winter wheat were available to the geese. A description of Horseshoe Lake is provided by Hanson and Smith (1950:116–120).

RESULTS AND DISCUSSION

Geese are tractable in their responses to various conditions influencing roosting and feeding locations and times of flight. Differences in local movement patterns are to be expected in different locations, depend-

ing, for example, on food supply and human activity. Certain relationships, however, are probably not basically altered regardless of human contacts.

Roosting Areas and Flight Directions of the Flock as a Whole

The general pattern of the Crab Orchard flock (up to 50,000 + geese) was as follows: the geese roosted at night on Crab Orchard Lake; on clear days they fed in surrounding fields in the early morning and late afternoon, returning in the midday to Crab Orchard Lake to loaf along shorelines and mud flats with a few geese staying in fields on or near ponds; on cloudy days, the geese remained in fields longer, all day, or flew back and forth to the lake.

At Horseshoe Lake on Union County refuges, large numbers of geese often spent much of the midday in wheat and other open fields, even during clear weather. The night-roost water areas were nearby, but they were much smaller than at Crab Orchard. The habit of day-roosting in fields or pond areas when night-roost areas are small, but returning regularly to large bodies of water for the midday has been noted also for pink-footed geese (*Anser fabalis*) and greylag geese (*Anser anser*) (Brotherston 1964).

The geese were not randomly distributed in roosting areas nor were they continually mixing. The entire flock was distributed among several *major roosting areas*. As a general rule each subflock had its own characteristic flight pattern and direction and location of feeding and loafing areas (Fig. 1). Different roosting subflocks sometimes fed in the same fields, especially after corn was harvested, but when they returned to the lake they often divided into separate roost locations.

Early in autumn the first geese to arrive fed in hay or wheat fields adjacent to the lake. As soybeans and subsequently corn were harvested the geese shifted to these fields. Harvested fields adjacent to the lake were fed in first. As food was exhausted the geese moved to the nearest fields, but in the same general flight direction taken to the first-used fields. The general pattern was similar to a series of concentric circles out to and eventually beyond the refuge boundaries with each subflock generally maintaining its identity. This pattern was stable through December and into early January. By that time refuge corn was depleted, hunting was over, and geese began feeding away from the refuge. Flight directions for most subflocks were still the same as early in the season. Some subflocks, however, shifted to roost areas which had previously been open to hunting. These new roosting locations represented water areas adjacent to where a subflock was feeding and where they were not unduly disturbed. Regardless of whether a subflock was flying 100 yards or 10 miles to a feeding area its roost location seemed to be the nearest suitable water area in relation to food sources being used.

The almost 360° direction of flight of the Crab Orchard flock as a whole reflected a relatively even distribution of food, particularly corn, around the roost lake. Numbers of geese moving in different directions were, however, unequal. When thousands of geese were feeding in one field, the sound and sight of them were powerful stimuli attracting other geese flying by or feeding nearby.

Habit apparently played an important role in conditioning local patterns of movement and use of areas. Often in late winter during cloudy days geese stayed in fields in the midday which had been exhausted of food 1 to 2 months previously, but that had been fed in consistently earlier in the year.

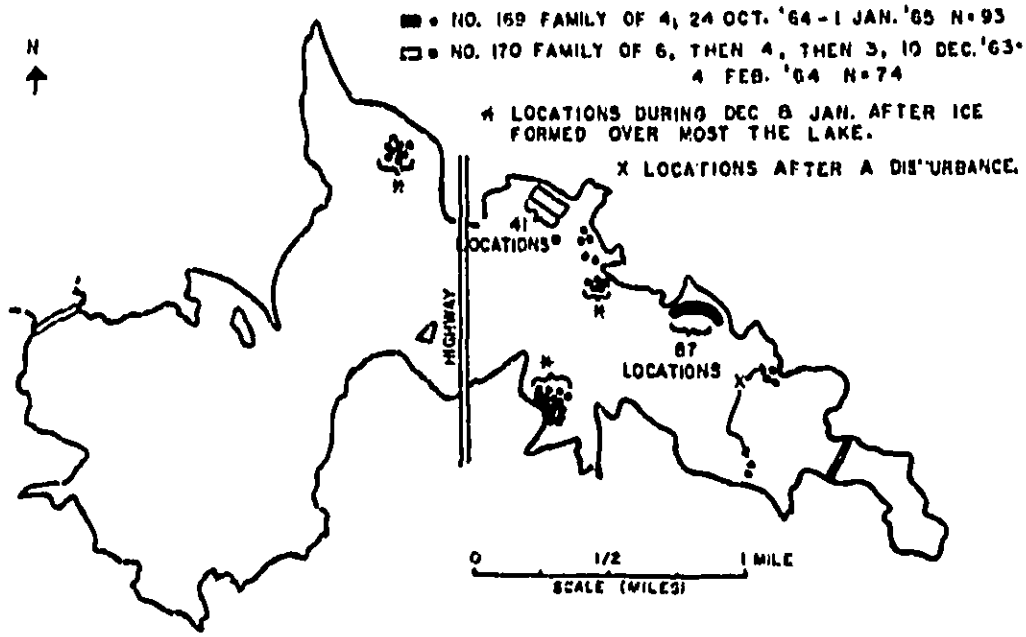

Fig. 2. Night and day roost locations on Crab Orchard Lake of radio- and color-marked single Canada geese.

Once geese were accustomed to using an area for roosting or feeding they were much less prone to constant alertness and the tendency to flee. Any new area or irregular situation, however, caused a notable increase in alertness and tendency to flee. Heinroth (1911:626) described the great timidity of geese in new situations, but with familiarity they selectively learned what not to fear. Heinroth concluded that fear occasioned the attachment of wild geese to their "own" pond and fields. Craighead and Stockstad (1956:228–331) also noted strong attachment of Canada geese to certain areas and consistent flight patterns.

Roost Locations of Radio- and Color-Marked Geese

Illustrated in Fig. 2 are all known lake-roost locations of two different families. The family record for No. 169 was most complete and during the period of transmitter operation no ice formation occurred to cause the geese utilizing that bay (Fig. 2) to leave for other open water areas. The data for family No. 170 include roost locations before, during, and after ice formation. When the ice thawed this family returned to the area it had habitually used before freezing occurred. Excluding locations occasioned by ice, it is apparent that these two families were highly consistent in their use of a specific bay for roosting, both day and night. This consistency explains the regularity noted for the flock as a whole and its division into subflocks.

No locations were recorded in the middle of the night, but sometimes locations of radio-geese were recorded after their return to the lake at nightfall and these proved to be the same as their locations in the morning before flight. The total number of lake-roost locations does not represent the maximum number possible, that is, two locations

Table 1. Utilization of Crab Orchard Lake roost-area(s) by pairs and families of radio- and color-marked Canada geese.

Group	*Number of Roost Locations and Inclusive Dates of Nearly Continuous Radio-tracking	Percent of Roost Locations in Contiguous Area(s) Used Most Often		Length of Shoreline or Lake Area Represented in Most Often Used Roost Area(s)—(Miles)
No. 15 Sibling Yearling Pair (males)	97 20 Oct. 1964–20 Jan. 1965	A. B. C.	39.2 17.5 14.4	0.29 0.30 0.26
		Total	71.1	0.85
No. 149 Pair	73 17 Nov. 1964–28 Jan. 1965	A. B.	50.8 37.0	0.21 0.17
		Total	87.8	0.38
No. 40 Family of 3	30 10 Jan.–13 Feb. 1964		96.7	0.18
No. 169 Family of 4	91 21 Oct. 1964–1 Jan. 1965		95.6	0.24
No. 171 Family of 5	40 10 Jan.–22 Feb. 1964		93.0	0.21
No. 188 Family of 5	40 8 Nov.–6 Dec. 1964		85.0	0.15
No. 170 Family of 6; then 4; then 3	40 10 Dec. 1964–4 Feb. 1964		89.2	0.14
Averages All Families			92.3 Ranges 85.0–96.7	0.18 0.14–0.24

* Excludes known roost locations that resulted from: (a) ice formation causing geese to shift from "normal" roost area(s) to remaining open water areas on Crab Orchard Lake (12 for No. 15 pair; 8 for No. 149 pair; 10 for No. 40 family; 17 for No. 171 family; 2 for No. 188 family; 38 for No. 170 family); (b) disturbance (2 each for No. 15 pair and No. 169 family and 1 for No. 149 pair).

per day. Often on completely cloudy days geese did not return to the lake after the morning feeding period. If they did return to the lake, they remained there only a short time before flying back out and their locations were not recorded. Afternoon flight times were not as predictable as morning times and sometimes instrumented geese had left the lake before their locations were recorded.

Regardless of the numbers of individuals in a family, all groups from which continuous data were collected exhibited a pattern of utilizing only one specific area of the lake (Table 1). Families utilized only one particular area for over 90 percent of their roost locations and these locations were grouped on the average within less than 0.2 miles of shoreline–lake area. Data presented in Tables 1 and 2 were extracted from maps prepared for each individual and family and represent a summarization of information such as presented in Figs. 2 and 3.

Data from five other families were too incomplete to warrant inclusion in Table 1. Mortality, transmitter failure, and disappearance from Crab Orchard resulted in incomplete data for four families. The fifth family (5 individuals) used one area for 14 days from the time they were released until the lake had mostly frozen over. They then left the refuge and were located with several hundred other geese at a nearby lake. Regular recording of their locations away from the refuge was not attempted. This

Table 2. *Utilization of Crab Orchard Lake roost area(s) by single radio- and color-marked Canada geese.*

Individual	*Number of Roost Locations and Inclusive Dates of Nearly Continuous Radio-tracking	Percent of Roost Locations in Contributing Area(s) Used Most Often		Length of Shoreline on Lake Area Represented in Most Often Used Roost Area(s)—(Miles)
No. 82 Single Adult Male	30 18 Oct.–28 Nov. 1963	A.	53.4	0.53
		B.	26.6	0.38
		Total	80.0	0.91
No. 182 Single Adult Male	33 22 Oct.–28 Nov. 1964		63.7	1.00
No. 178 Single Yearling Male	118 26 Oct. 1964–27 Jan. 1965		90.7	0.62
No. 28 Single Yearling Male	42 20 Dec. 1964–29 Jan. 1965	A.	30.9	0.30
		B.	28.6	0.20
		Total	59.5	0.05
No. 41 Single Yearling Female	46 20 Dec. 1964–24 Jan. 1965	A.	39.2	0.56
		B.	31.8	0.32
		C.	15.2	0.14
		Total	89.2	1.02
No. 39 Single Yearling Female	40 12 Dec. 1964–30 Jan. 1965	A.	30.0	0.27
		B.	22.5	0.14
		C.	17.5	0.27
		Total	70.0	0.68
No. 71 Single Yearling Female	33 15 Jan.–10 Mar. 1965	A.	57.5	0.67
		B	24.2	0.23
		Total	81.7	0.90
Averages All Single Geese			70.7	0.83
		Ranges	59.7–90.7	0.62–1.02

[a] Excludes known roost locations that resulted from: (a) ice formation causing geese to shift from "normal" roost area(s) to remaining open water areas on Crab Orchard Lake (9 for No. 39; 3 for No. 71) or shift to a nearby lake (13 for No. 28; 17 for No. 41; 10 for No. 39); (b) flooding after February rains (23 for No. 71); (c) use of a pond as refuge for day-roosting (18 for No. 178).

family returned to Crab Orchard after 14 days and then roosted in a new location consistently for 13 days. They again moved to the other lake and were recorded only a few times back at Crab Orchard before all transmitters failed. While this family was more variable than the others, the pattern was similar: it regularly was recorded in an area until it moved, after which it consistently utilized the new area until it moved again.

Summaries of roost locations of a yearling sibling pair (see Raveling 1969) and a mated pair are also listed in Table 1. Both pairs consistently roosted in more than one area. In addition to favoring more than one roost area, they were located more often away from their most used areas than were family units containing immatures.

In contrast to the very habitual usage of roost areas by families, single geese exhibited a *more* scattered pattern (Fig. 3; Table 2). Single geese tended to roost in circumscribed areas but usually more than one site was utilized and the total area representing the majority of roost locations was much larger for singles than for families. A

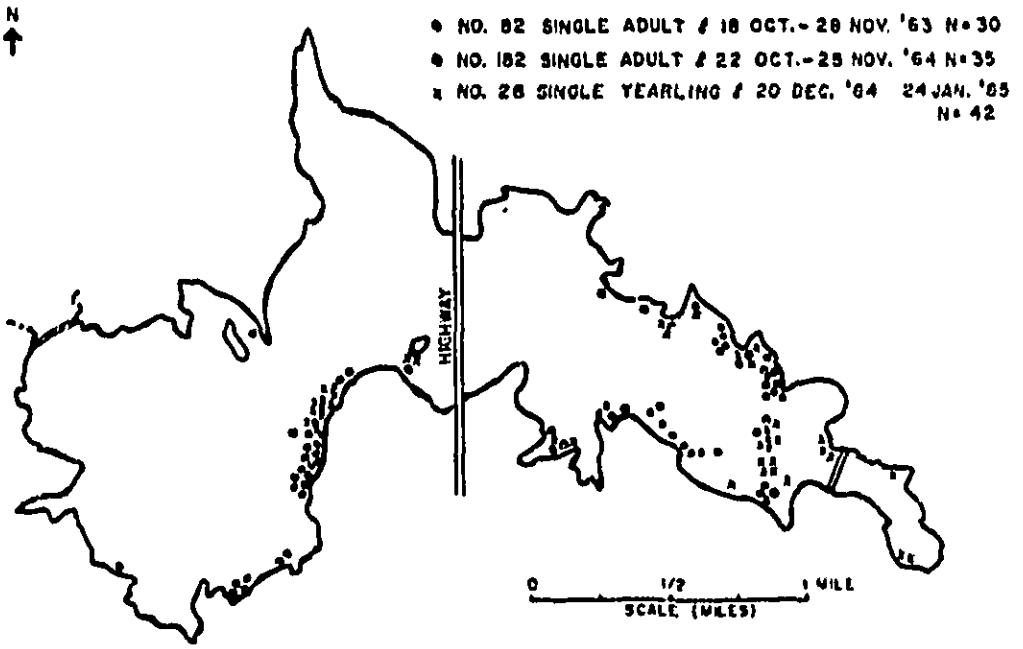

Fig. 3. Night and day roost locations on Crab Orchard Lake of 3 radio- and color-marked single Canada geese

larger percentage of locations of singles was away from the most used areas.

Roosting mostly in two or three areas by singles did not necessarily represent consistent use of one area and then a switch and consistent use of another area. An individual often returned to roost locations used somewhat consistently earlier and there was not the attachment to one specific site within a roost area as there was with *families*.

Strong winds which created whitecap waves on the lake caused geese to shift into bays sheltered from the wind. Sometimes when it was very windy the geese flew from the lake to the fields.

Direction of Flight and Feed-field Locations in Relation to Roost Locations

As well as roosting in the same area (Fig. 2), families nearly always flew in the same general direction when going out to feed. Wind direction influenced the initial take-off direction of geese but not their destination. Conversely, single geese utilized many different roosting areas made up of different subflocks (Fig. 3) and their directions of flight and utilization of feed-fields were more variable. Summarized in Fig. 4 are compass directions of flight to feeding areas in relation to the roost location for singles, pairs, and families of Canada geese. These directions are a direct reflection of the constancy of roost locations of families and the more variable pattern of singles. The single yearling most constant in use of a roost area (No. 178, Table 2) was also the most consistent in flight direction (Fig. 4, C).

Single geese were followers, commonly flying in unison with other geese (*Raveling* 1968) and the directions in which they flew were often determined by the groups of geese they happened to be near at the

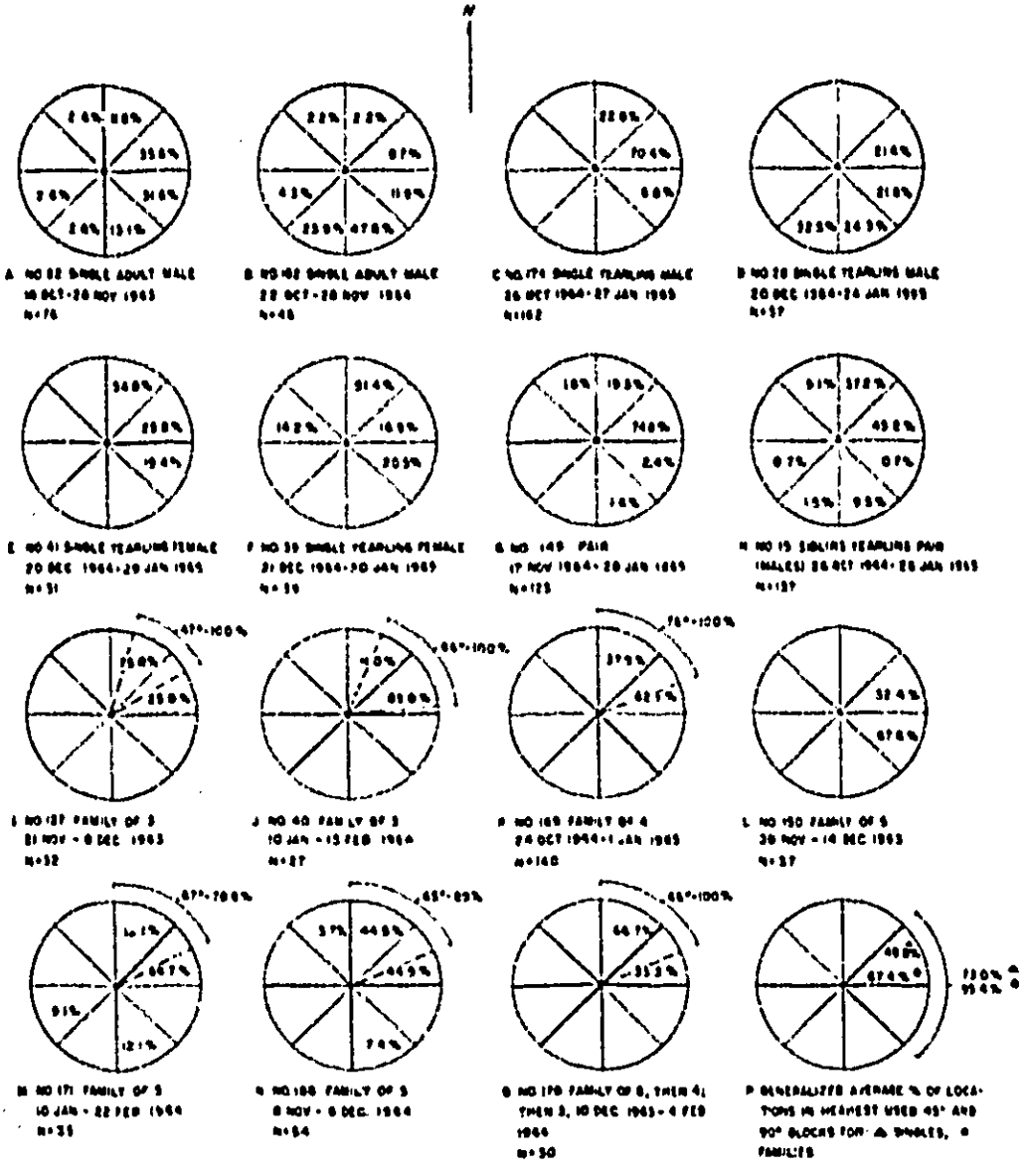

Fig. 4. Directions of feed—field locations from lake roost locations of singles, pairs, and families of radio- and color-marked Canada geese.

time of flight. Since more than one subflock often used the same feeding area, a single might return to the lake with a subflock different from that with which it left. Since singles were not as strongly attached to certain areas of the lake or certain fields as were families, if they returned to a different part of the lake they frequently remained there instead of moving to an area of more habitual use.

An additional factor that appeared responsible for a single's variable use of roosting sites was its submissive position in the flock (*Raveling 1967:61-68*). Singles frequently swam slowly along the shore and were often threatened or avoided contact with other geese established in a loafing area. When a single stopped in an area and was not chased, the area was often a considerable distance from where the goose had first attempted to go ashore or loaf in the water. Dzubin, Canadian Wildlife Service (*Personal communication*) has observed that white-fronted goose (*Anser albifrons*) families dominate "favored" shoreline roosting areas and what appeared to be singles and non-productive adults were more predominant in the water. Such a pattern appeared true for Canada geese at Crab Orchard.

However, locations of singles were not completely fortuitous. Even though variable and influenced by movements of geese they were with, singles still exhibited some degree of attachment to certain areas. This is shown by their use of some locations more than others and their ability to return to these roost sites, even after they had become mixed with geese from other areas.

In contrast to a single, a family not in its usual roost location (usually because of ice formation) usually flew in its customary direction and utilized fields regularly used before the shift in roost location rather than conform to the pattern of the majority of geese in their new area. For example, when ice forced family No. 170 to utilize an area on the south side of the lake (Fig. 2) it did not fly south as did the geese usually using that part of the lake (see Fig. 4, O for family's pattern and Fig. 1 for general pattern when no ice), but continued to fly north and northeast. During periods when ice forced great numbers of geese to concentrate around a few open water areas, concentrated flights in two or three directions away from this common roost location were observed, as families maintained their traditional flight patterns.

Functions Served by Consistent Roost and Feeding Area Utilization

Consistent use of a small roosting area by families was important in enabling separated family members to be reunited. Often when geese were flushed from a feeding area (for example, by predators, airplanes, or humans) family members would be separated. After disturbances geese often landed toward the middle of the lake as much as 300 yards from their traditionally used roost site. They did not swim about randomly, but within a few minutes usually moved to their habitual roost area and separated family members regrouped.

In one instance a family became separated by hunting and because ice had covered its traditional roost site, one immature returned to one open water area and the gander and other two young returned to a different open water area. This immature remained separated for 8 days until he walked across the ice to the open water area used by the remaining members of the family and was reunited. In this instance the family involved had been unable to return to its usual haunts on the lake.

The more variable pattern exhibited by one family and the pairs, especially the sibling yearling pair, demonstrates that related birds can remain together even if they do not always use the same roosting area. Occasionally, large numbers of geese change roosting locations and as long as all family members are together when such a move occurs, little chance for separation exists. Another mechanism of reunification of separated family members is their return to the place where separation occurred. This con-

tributed to vulnerability to hunting (Hanson and Smith 1950:127).

Utilization of the same areas by the same geese should also encourage efficient use of food sources and minimize numbers and intensity of aggressive conflicts within a flock. Canada geese exhibit a rigid rank order of large family > small family > pair > single (Hanson 1953, Raveling 1967:61–70). Larger families are involved in more frequent and intense aggressive encounters than small families, pairs, and singles (Raveling 1967:78–81). If families continuously shifted roost areas they would constantly be in association with other families of equal or near equal dominance status with which no rank relations had been established. Such a situation would lead to more aggression than is necessary when a large number of geese utilizing an area are already familiar with each other. This was indicated when freezing conditions forced geese from more than one subflock to take up new roost locations around a few open water holes. During these cold periods it was noted that more chasing, *Triumph ceremonies* (Fischer 1965, Raveling 1967:18–33), fighting, and near fighting occurred as the geese became active when it warmed in the afternoon. While such an increase in total aggression for the flock as a whole was not quantified I believe it occurred and is related to the fact that geese unfamiliar with one another were together. However, when geese are in new situations the result is comparable to disturbances in that many triumph ceremonies are elicited (Fischer 1965:288). The performance of many triumph ceremonies itself is predisposing to an increase in the number and intensity of aggressive encounters.

One family of five (the most aggressive marked group of the study) was observed for a total of 201 min (from 2 days) within 2 hours of the time when they flew from their traditional afternoon roost site. During this time the family, or individuals within the family, were involved in nine aggressive encounters, or approximately 2.7 conflicts per hour. This same family was observed 351 minutes (from 6 days) within 2 hours of the the time of afternoon departure from a new roost site at an open water hole during a period of ice cover. During these observations the family, or parts of it, were engaged in 29 conflicts, or 4.9/hour. Although these records are limited, they confirm that more conflicts occurred in a situation when "strange" geese were forced together and that a likely function of traditional use of roost areas is to limit aggression and promote stability.

Possible Relationships of Certain Subflocks to Different Nesting Areas

As indicated in Fig. 1, there was nearly complete separation of the geese utilizing the east side of Crab Orchard Lake from those using the west side. Observations of migrant geese arriving at the refuge suggested that there may exist a more significant difference between subflocks than merely a stratification due to development of local habits after arrival. Some migrant flocks passed over Crab Orchard, presumably on their way to Union County or Horseshoe Lake or even more southern locations. On other occasions a migrant flock would start to descend, some landing and others continuing on. These geese seemed familiar with their destination, not only a specific refuge, but a specific part within the refuge. Usually the Crab Orchard goose flock builds up to 50,000–60,000 individuals; then a large number (up to 20,000) depart, even before food supplies are exhausted. The geese departing during this study were primarily those on the west side of the lake.

These observations, together with the knowledge gained of the habitual and relatively exclusive use patterns of the various subflocks, suggest that different segments of the same contiguous breeding population may maintain their identity during migration and through the winter season.

Indirect evidence that various segments of a large population may remain together throughout the year was provided by observations of blue and snow geese (*Anser c. caerulescens*) at Squaw Creek National Wildlife Refuge in northwest Missouri (Holt County) in December, 1965. Squaw Creek is a relatively small refuge (8,800 acres) which contained approximately 70,000 blue and snow geese at the time of my visit. It was obvious that this concentration of geese was largely divided in two main flocks on opposite sides of the refuge; a situation analagous to the Canada geese at Crab Orchard, but even more distinct. Examination of photographs of each subflock demonstrated that there were many more blue phase geese in the flock on the east side of the refuge (38.8 percent; (N) 374 identifiable in photo) than on the west side (20.5 percent; (N) 366 identifiable in photo). The percentage of blue geese in the east subflock (which had more geese than the west subflock) was almost identical to that found in populations nesting on Southampton Island, Northwest Territories, Canada, and the percentage of blue geese in the west subflock was approximately equal to that of the geese nesting at McConnell River, Northwest Territories, Canada (Cooch 1963). This strongly suggests that these subflocks represented different breeding populations wintering together but retaining their identity.

Management Implications

Knowledge that a large flock of geese at a single refuge is segmented into varying numbers of subflocks with different patterns of consistent use of lake areas, flight directions, and feeding locations has implications for several aspects of management and study of goose populations. Of necessity, analyses of banding data have required treating the banded samples as random and as a true cross section of a population. It is now becoming more and more evident that for the most meaningful understanding of goose populations it is essential to know the subspecies (Hanson 1965), sub-populations within a race (Hanson and Smith 1950:71–79), and even the subflocks of one local flock.

Trap samples at refuges are usually taken in few locations. The stratification of subflocks such as demonstrated at Crab Orchard show that in any one year, parts of a flock are banded at a relatively high rate while other portions are not. Similarly, food distribution within a refuge and hunting pressure around refuges are seldom equal and certain parts of a goose flock may be heavily shot while other subflocks may be almost unharvested. Whether or not a particular subflock is more exposed to hunting as related to whether or not it has been heavily banded could bias interpretations of the magnitude of local kill as well as conclusions on the distribution of the flock and kill in other areas. This bias would be most prevalent if subflocks maintain a tradition of use of local areas for more than one season.

Other data gathered from portions of a flock could be misleading as an index to the entire flock. For example, age ratios from traps, kills, or group counts (Lynch and Singleton 1961, Raveling 1968) may represent a distortion if different segments of a flock had a different breeding success or hunting mortality and were distributed differentially on the area where they were sampled.

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